

Methods,
PROPOSITIONS and PROBLEMS,

FOR
Finding the Latitude;

533.e.24
5

With the Degree and Minute of the Equator
upon the Meridian.

AND

The Longitude at Sea.

By Cælestial Observations only.

And also by Watches, Clocks, &c. and to
correct them and know their Alterations.

By ROBERT BROWNE. K

L O N D O N.

Printed by R. Tooke, for the Author, and are sold at his
House at St. Catharine's Dock, and by J. Harrison, at the
Corner of Castle-Alley, on the Royal Exchange. 1714.
(Price 6d.)

p. 286

Method

PROBLEMS AND SOLUTIONS

ДОТ

...the I. and ...

Which the Board and the Trustees of the University

Q F A

The thought of her.

BY CORRECTION OFFICIAL

and they are now in the hands of the
authorities.

ROBERT L. HAYES

L O M D O A

1000

To the Right Honourable and Honourable, The Commissioners appointed by Act of Parliament, for providing a Publick Reward for such Person or Persons, that shall find the Longitude at Sea.

I Humbly offer, that I have for several Years past, apply'd my self to the Study of Astronomy and Navigation, and contriv'd several Methods and Instruments for finding the Latitude and Longitude at Sea, certified and approv'd by the Reverend Mr. John Flamsteed, M. R. Dr. Edmund Halley, and other Artists; that not being Encouraged, I was oblig'd to lay those Improvements by, which I humbly hope will now meet with Encouragement from your Honours, that I may lay before you to what perfection they may be dependee on by Land, and also the Probability of finding the Longitude at Sea, to a certain Degree of exactness, within the Limits of the said Act. I have therefore thought fit to publish this, as an Index to a Manuscript I have prepared, demonstrated and prov'd by Observations made by my self to each Problem, -- Which I humbly submit to your Consideration and Encouragement, and am,

Your Honour's

Most humble and obedient

Servant, to command,

Rob. Browne.

Mc-

To the Right Honourable and Honourable, The Commissioners appointed by Act of Parliament for providing a Publick Reward for such Person or Persons, that shall find the Longitude at Sea.

Methods,

PROPOSITIONS and PROBLEMS,

(&c.)

Proposition 1.

TO Contrive, make, or immediately produce, portable Instruments for making the following Observations by Sea or Land: And the most correct and easiest Tables extant, for computing the Sun and Moon's true Places, &c. as may appear by the following Examples of the Moon's Places, produced by my Tables, and also by Sir *Isaac Newton's* Theory, compar'd with 25 correct Observations of the Moon's true Place, made by Mr. *Flamsteed* at the Royal Observatory at *Greenwich*, being all the true Places of the Moon I have yet obtain'd, that I can depend on, to correct and improve my Tables by; so that if by further tryal there should appear a greater deficiency, in all probability I may correct and make my Tables much better, if I can obtain a sufficient number of those correct Observations to work upon, or it's like Mr. *Flamsteed* will in a short time produce better Tables of his own, which may answer Expectation

SEVERAL TO COMMISSIONERS

Rob. Brown.

Mc-

An

(23)

An Example of my Tables for computing the Moon's Place, compar'd with the Observations and Sir Isaac

Newton's Theory

Anno	Apparent Time.	Lat. D	Obs.	dis T.	Long. D	Obs.	dis T.	dis. th.
	Mon. D. H. m. "							
1677	Feb. 8 16 12 45	S. 4	56 35	0-53	W 18	51 37	2-20	2-6
1678	Jan. 22 7 8 19	S. 2	20 07	0+20	W 19	25 27	1+39	0-7
1678	July 17 9 38 13	N. 9	26 20	0-14	W 17	08 58	1+33	5+22
1680	Aug. 26 11 12 42	N. 4	8 29	1-29	W 8	47 28	0+11	2-0
1690	Jan. 16 7 57 15	N. 4	48 59	0-16	W 18	17 22	1+31	6+13
1690	Jan. 23 11 12 19	N. 4	38 19	1-17	W 21	34 37	0+14	6+6
1690	Feb. 2 2 25 19	N. 0	39 29	0-10	W 3	57 51	1-35	2+35
1690	Feb. 5 4 51 50	N. 3	59 52	0+10	W 16	30 10	0-28	5+8
1690	Feb. 7 6 49 00	N. 5	08 27	0-31	W 15	56 50	0-38	3+20
1690	Feb. 8 07 51 23	N. 0	13 17	0-38	W 0	15 24	1-21	5+17
1690	Feb. 10 9 57 7	N. 4	20 45	1-5	W 0	54 24	0-14	4+27
1690	Feb. 12 10 53 33	N. 2	26 35	0-41	W 15	41 48	0-38	3+37
1690	Feb. 14 13 18 5	S. 0	8 46	0+1	W 28	11 05	1+10	8-13
1690	Feb. 19 17 2 44	S. 4	45 28	2+3	W 2	22 54	0-32	8-32
1690	Feb. 21 18 45 22	S. 5	14 52	1+31	W 27	0 22	0+7	9-24
1690	Mar. 7 5 50 38	N. 5	17 15	0+5	W 26	22 9	0+6	9-24
1690	Mar. 11 9 44 31	N. 9	49 20	0-43	W 14	17 19	0+47	5+8
1690	Mar. 13 16 18 18	N. 9	24 19	0-13	W 27	15 30	3+15	4+2
1690	April 7 7 49 26	N. 2	17 29	1-4	W 20	10 45	0-6	8+32
1690	April 8 8 36 30	N. 1	0 10	0-35	W 4	0 54	0-14	5+38
1690	April 9 9 22 00	N. 0	48 39	0-42	W 17	22 19	5-20	9+9
1690	Nov. 14 19 50 50	S. 1	19 33	0+44	W 29	41 56	5-31	9-29
1697	Oct. 19 12 10 00	S. 8	55 00	0+27	W 9	54 52	1-41	3+36
1697	Nov. 17 11 44 53	S. 2	57 00	0+7	W 2	46 37	1+23	3+31
1629	Feb. 4 11 39 42	S. 13	22 13	0+7	W 20	15 31	1+21	6+0
1710	Feb. 26 10 54 49	N. 4	17 21	0+2	W 3	22 40	4+13	
1710	April 20 9 59 30	S. 3	57 41	0+14	W 10	52 20	8-46	
1710	Oct. 1 16 00 10	N. 1	0 10	0-35	W 19	0 20	2+21	
1710	Nov. 21 9 20 00	N. 4	57 41	0+14	W 10	52 20	8-46	

Observ. by
my self.

Problem 1.
How by the Meridional Altitudes of the
Sun or Stars, to determine the Latitude or
Place, with the Sun's greatest Declination.
Prop. 2.

Prop. 2.

To rectifie the Horizon, by an Equation for the Heigh of the Eye above the Surface of the Water.

Prop. 3.

To rectifie the Horizon when hazey or dusky, so that another Horizon is seen, nearer than the true Horizon.

Prop. 4.

To correct all Heights observed by the Refractions, to be subtracted from the Altitudes observed.

Prop. 5.

To contrive, make and manage Observations, so that by them frequently to determine the Latitude and Longitude of any Place, or Ship at Sea, &c.

First, For obtaining the Latitude, with the Right Ascension of the Meridian, Mid-Heaven, Medium Cœli, or Degree and Minute of the Equator culminating, accounted from the first Scruple of *Aries*.

Problem 1.

How by the Meridional Altitudes of the Sun or Stars, to determine the Latitude of any Place, with the Sun's greatest Declination,

on, or distance betwixt the Poles of the Equator and Ecliptick, supposing neither the Place or Declination of the Sun or any Star to be known.

Problem 2.

By observing the Meridional Distance of the Sun, or any Star, from the Vertex, their declinations being known, to determine thereby the Latitude of the Place.

Problem 3.

By observing the Meridional Distance of the Moon from the Vertex, to determine thereby the Latitude of the Place or Ship.

Problems 4.

By observing two Stars, whose right Ascensions are equal, upon the same Vertical Circle or Azimuth (which is the Meridian in this Case) with the Distance of one of them from the Vertex, to determine thereby the Latitude of the Place, and R. A. of the M. C. (which is equal to the R. A. of the said Stars) and consequently the Hour of the Night.

Problem 5.

By observing the Distance of two Stars from the Vertex, reduced to one Time, to determine thereby the Latitude of the Ship, with the R. A. of the M. C. &c.

By

(8)

By this Method, tho' the Observations or Instruments be unexpectedly defective 20 or 30 Minutes, it will only produce an Error of four or five Minutes in the Latitude, and if choice be made of such Stars as are rising or setting nearly alike, and the Horizon or Instrument 20 or 40 Minutes false, the Error will not be two or three Minutes in the Latitude.

Problem 6.

By observing two unequal Distances of the Sun from the Vertex, and the Time betwixt them, to determine thereby the Latitude of the Place, with the R. A. of the M. C. at any one of them, &c.

Problem 7.

By observing two unequal Distances of the Sun from the Vertex, with the Sun's apparent Azimuth at each of them, to determine thereby the Latitude of the Ship, with the R. A. of the M. C. and Variation of the Compass.

Problem 8.

By observing two Stars upon the same Vertical or Azimuth Circle, and at the same time the Distance of one of them from the Vertex, to determine thereby what Latitude the Ship is in, with the R. A. of the M. C. &c.

Prob-

Problem 9.

By seeing two Stars whose right Ascensions are equal upon the Meridian, and the time betwixt that and two other Stars being upon another Vertical Circle, to determine thereby the right Ascension of the M. C. and Latitude of the Place or Ship. &c.

Problem 10.

By seeing two Stars upon the same Vertical Circle, and the time betwixt that and two other Stars being upon another Vertical Circle, to determine thereby the Latitude of the Place, and R. A. of the M. C. &c.

Problem 11.

By seeing two Stars upon the same Vertical Circle, and at the same Time two other Stars upon another Vertical Circle, to determine the Latitude and R. A. of the M. C. &c.

Notwithstanding several of these Problems are difficult for unskilful Persons to perform, and tedious in Operation, yet from them Methods may be reduced, that by Inspection only, the Mariner in the Night Time as he walks the Deck, may know the Latitude the Ship is in, and the R. A. of the M. C. Hour, &c.

Problem 12.

By seeing two Stars rise or set together, or the one rising and the other setting, to determine

mine the Latitude the Ship is in, and the R. A. of the M. C. &c.

Problem 13.

By observing the Distance of the Sun from the Vertex, and at, or reduced to the same Time, the Distance of the Moon from the Vertex, to determine thereby the Latitude of the Place, and R. A. of the M. C. &c.

Problem 14.

By observing the Distance of the Pole-Star from the Vertex, and at the same time nearly the R. A. of the M. C. by some of the former Methods, to determine the Latitude the Ship is in, &c.

Secondly, For finding the Longitude, with the Assistance of some of the precedant Problems.

Problem 1.

By observing the Distance of the Moon, from the Sun or a Star, and at the same time the Distance of the Moon from the Vertex, and also the Distance of the Sun or Star from the Vertex, to find thereby the Longitude of the Place or Ship at Sea, without calculating any of the Moons Parallaxes, her Parallax of Altitude only being known, this Method of evading the Trouble and Difficulty of computing the Moon's Parallaxes, is entirely my own Contrivance.

Prob-

Problem 2.

To find the Longitude by observing the Appulses or Distances of the Moon from a Star, within the Tube of a Telescope, which is exactly measured, by fixing Threads in the Aperture, at 5, 10, 20 or 30 Minutes to a Degree, or greater Distance asunder, this Method is also my own Contrivance, with the easie and correct way of computing the same, being the only Method ever contrived for that Purpose.

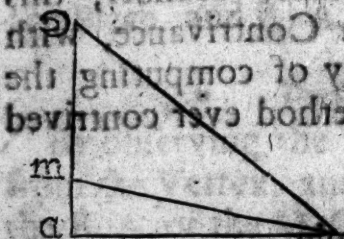
Example.

July the 16th. 1711 in the Evening, I observed the corrected Distance betwixt the Moon's Center and a Star in the left Shoulder of *Sagittarius*, $1^{\circ} 50'$ being just the Aperture of the Telescope, the Moon being about $20'$ higher than the Star, and at the same time the Distance of *Cor Scorpio* from the Vertex, corrected by Refractions, $81^{\circ} 18'$.

Hence by Problem 5. of the first Part, the Latitude, being near *London*, will be found to be $51, 30$, & the R. A. of the M.C. $271^{\circ} 43'$ R. A. of the Sun by our Tables, subst. $126 32$ Leaves the R A of Time,

	145 21
Therefore the apparent time P M	$9^h 41' 28''$
Equation of time, add	$5' 49''$
Equal time P M	$9^h 47' 17''$
at which time the Longitude of	
the Moon by our Tables is	$\left. \begin{array}{l} \\ \end{array} \right\} \begin{array}{l} \text{w } 102^{\circ} 8' \\ \text{Lon-} \end{array}$

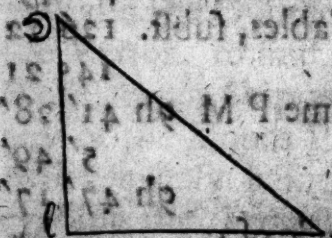
Longitude of the Star w 8 21 12
 Difference of Longitude betwixt
 the Moon and Star 3 49 58
 Latitude of the Moon by our Tab. S. 2 42
 Latitude of the Star South 3 33 32
 Diff. betwixt their Latitudes 1 26 20
 The Moon's parallax of Altitude 0 58 0



Therefore, in the plain triangle m^* right angled at d , is known, m^* the distance betwixt the Moon and the Star observ. 1 50' = 110

with d the Height of the Moon above the Star, observ'd, to find a the difference betwixt the Azimuth of the Moon and Star = 108 1.

Secondly, In the Triangle c^* are known, a 108 1, with c the Height of the Moon above the Star, added to her Parallax of Altitude, = 78, to find c^* the true Distance betwixt the Moon and the Star, from the Center of the Earth, = 133, 4.



Thirdly, In the plain Triangle c^* right angled at l , is known, c the difference betwixt the Latitude of the Moon & Star, 1 26 20' = 86,

with c^* the true Distance betwixt the c & $* 133,$

* 133, 4, to find the Difference of Longitude betwixt the Moon and Star by Observation, $101^{\circ} 7' 41''$, from which take the Difference of Longitude computed, $55''$, leaves the Difference, $46''$ which in Time, by the Moon's motion, is $1^m 13''$, equal to 18 Geographical Miles, the Difference of Longitude by this Method, betwixt the Place of Observation and London, which, because the Moon's Longitude found by Observation, is more than the Longitude found by Computation, the Place is 18 Miles East from London.

Problem 3.

By observing an Eclipse of the Sun, to determine the Longitude of any Place, or Ship at Sea, and how to compute and describe the true Figure of the Sun's Eclipse, in any Part of the World, at any Interval of Time, by a new and correct Method.

Problem 4.

By observing the Moon eclipsed, to find thereby the Longitude, and how to compute and describe the Figure of the Moon's Eclipses, &c.

Problem 5, and 7.

By observing the Distance of the Moon from two Stars, reduced to the same Time, to find the Longitude thereby.

Prob-

Problem 6 and 8.
To find the Longitude by observing the distance of the Moon from one Star.

Problem 9.
To find the Longitude by observing the distance of the Moon from the Vertex.

Problem 10.
How by one or more well regulated Watches, or any good Time Keeper, to determine the Longitude of the Place or Ship at Sea, and how to correct them and know their Alterations.

Case 1.

Having provided such Watches or Time-keeper, how to correct them that at the Departure from any known Meridian, they keep true Time with the Rotation or Transits of the Equator over the Meridian.

Admit that at London on the 15th Day of Feb. 1711, I observed the Distance of the Sun from the Vertex in the Forenoon, $70^{\circ} 36'$ and the estimate Time be 15^m past Nine, at which Time the Declination of the Sun is by our Tables, $8^{\circ} 53' S$. the Distance of the Sun from the M C will be found, $42^{\circ} 30' 28''$ and the true apparent Time 10^m past 9, at which Time the apparent Place of the Sun will be, $\approx 7^{\circ} 11' 50''$, and his right Ascension $338^{\circ} 54' 50''$, from which take the distance of the Sun from the M C by Observation, $42^{\circ} 30' 28''$, leaves the true right Ascension of the M C $296^{\circ} 24' 22''$, which converted into Time, is $19^h 45^m 37^s$, then

then admit it were 3 Hours from the Time of Observation to the Time of correcting your Watch or Clock, at that Moment add 3 Hours to $19^h 45^m 37$ and set the Watch or Clock to $22^h 45^m 37$, or $10^h 45^m 37$, then is the Watch or Clock set to keep Time with the Rotation of the Equator at *London*, then by observing and computing several Days and Times the R A of the M C, will be found exactly what Time the said Watch or Clock keeps with the Rotation of the Equator over the Meridian, and consequently the Watch or Clock accommodated to keep the same time. Or Equations must be made, whereby to correct them, so that the Difference at all Times and Places, betwixt the R A of the M C found by Observation, and the Time by the Watch or Clock so corrected, turn'd into Degrees and Minutes, will be the true Difference of Longitude betwixt the Place of Observation, and *London*, provided the said Watch or Clock do not alter, which undoubtedly they will, therefore,

Case 2.

How to know the Alterations of the said Watch or Clock, and to make Equations to correct them.

Admit that at any Time we take our Departure from *London*, or any other Place, having a Watch or Clock provided and fitted to the Meridian as aforesaid, and regulated to the Motion or Rotation of the Equator as directed,

ed, we must at several Intervals of Times, as Opportunity will permit, find by Observation the R A of the M C at one two or three Hours distance, and if it may be, sometimes lie by with the Ship, till such Observations are made, and thereby find what Time the Watch or Clock keeps with the Transits of the Equator over the Meridian, and by this Means it will be discover'd whether the watch or Clock keeps the same Time as at the Departure; if not, Equations or Proportions must be made to correct them accordingly; but if at the Time of such Observation the Ship be under Sail, upon any Tack her way must be curiously kept and corrected by the Latitudes observed, that the difference of Longitude made upon such Tacks, may be accounted for, by the best and surest Methods of Mercator sailing, which being skilfully accounted for, the Degrees and Minutes of the Equator upon the Meridian at the several Observations, will shew the Alteration of the said watch or Clock, &c.

Hence, when the Longitude is found by these several Methods of attaining it, and compar'd together, undoubtedly a Medium will come near the Truth, and the Longitude ascertain'd to a sufficient exactness.

the Meridian as storied, and regulated to the Motion or Rotation of the Equator as direct.

Gla
with
ther
larg
port
at th

A Sextant of three Foot Radius, with Sights to
the Sun, and with the Sun Eye, for taking of the
Altitude of the Sun, Moon, or Stars, and with one
two, three, or four Minutes of the Truth.

A Description of the Instruments I have made and provided, for making the Observations, and performing the precedent Problems, accommodated either for Sea or Land.

1.
A Quadrant of twenty Inches Radius, with a Telescope of two Foot for taking the Altitude, or Distance from the Vertex, to about two Minutes. With a Box and Needle to screw to the Plane of the Quadrant, to take the Azimuth of the Sun, Moon, or Stars, together with the Altitude, whereby to determine the Variation of the Compass, when it can be used.

2.
A Quadrant of three Foot Radius, with a Telescope for taking an Altitude to one Minute, the Aperture large, and Threads fixed at several Distances, for taking the Appulses of the Moon or Eclipses, &c.

A large Tube fixed to an Arch, with an Eye Glass and large Aperture, to turn about, fixed with Threads at several Distances, and several other Tubes, with Object Glasses to slide into the large Tube, fitted to several Lengths, to use as Opportunity will permit, for taking the Apulses, and at the same Time the Altitudes also.

A Sextant of three Foot Radius, with Sights to use by Hand with the bare Eye, for taking of Distances, or Angles to sixty Degrees, and within one, two, three or four Minutes of the Truth.

A Description of the Instruments I have
 - Brazil Sticks, with Lead fixed at one End to make them hang perpendicular, to see when two Stars are upon one vertical Circle.

A Quadrant of twenty Inches Radius, with a Telescope of two Foot Length, for taking the Altitude or Distance from the Zenith to about two Minutes.

Postscript.

About three Years past, I apply'd my self to the Honourable South Sea Company, by a Petition. The Gentlemen whole Hands I obtain'd to the same, being before acquainted with my Ability and Methods, certified for me as follows,

A Quadrant of three Foot Radius with a Telescope of two Foot Length, for taking the Altitude or Distance from the Zenith to about two Minutes.

That the Petitioner has for some Years past apply'd himself to the Study of Astronomy and Navigation, that he understands the Sphere, and both plain and Spherical Trigonometry, their Application and various Uses; that himself has made with his own Hands Instruments for observing the Latitude, and Method for finding the Longitude at Sea, by Celestial Observation.

Which Petition lay several Months at the same
 Office, but could not be answered: so that I have
 not been able to tell in Business, and being not used to
 the same, I have not been able to do so. I have
I Have known Mr. Browne this six Years, and be-
 lieve the Assertion of his Petition to be true.
 I am, Sir, Your Obedient Servant,
John Flamsteed, M. R.

I Believe the Petitioner may be very serviceable to
 the Honourable Company, in settling and ascer-
 taining the true Situation of the Coast of the South-
 Seas.

Edm. Halley.

I Know Mr. Browne, the Petitioner, so well quali-
 fied in the Mathematicks, which renders him ca-
 pable to improve Navigation, by settling the Lati-
 tude, Longitude, Bearing and Distance of Places,
 that may be of Use and Service to the Honourable
 South-Sea Company.

*James Atkinson, Sen. Teacher
 of the Mathematicks.*

Which

Which Petition lay several Months at the
Sea Office, but could not be answer'd; so that I hav-
ing settled my self in Business, and being not us'd to
the Sea, do not design to leave my Family, to take
a long Voyage; I therefore withdrew the said Peti-
tion: For the Methods I propose, may be as well
experienced near home, and being found effectual,
cannot be subject to any other Variations in any part
of the World, which if encourag'd, I shall daily be
improving and experiencing them, and keep a Jour-
nal of such Experiments and Improvements, if God
permit.

I Believe the Petitioner may be very serviceable to
the Honourable Company, in settling and ascer-
taining the true Situation of the Coast of the South
Sea.

Edm. Halley.

I Know Mr. Brouncker the Petitioner, to well quali-
fied in the Mathematicks, which renders him ca-
pable to improve Navigation, by settling the Lat-
itudes, Longitudes, Bearings and Distances of Places,
that may be of Use and Service to the Honourable
South-Sea Company.

James Adkins, Sen. Teacher
of the Mathematicks.
Which